PEEM Thermal Stress and Reliability

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Project Duration: FY08 to FY10

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Advanced Power Electronics and
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FY08 Kickoff Meeting

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This presentation does not contain any proprietary or confidential information

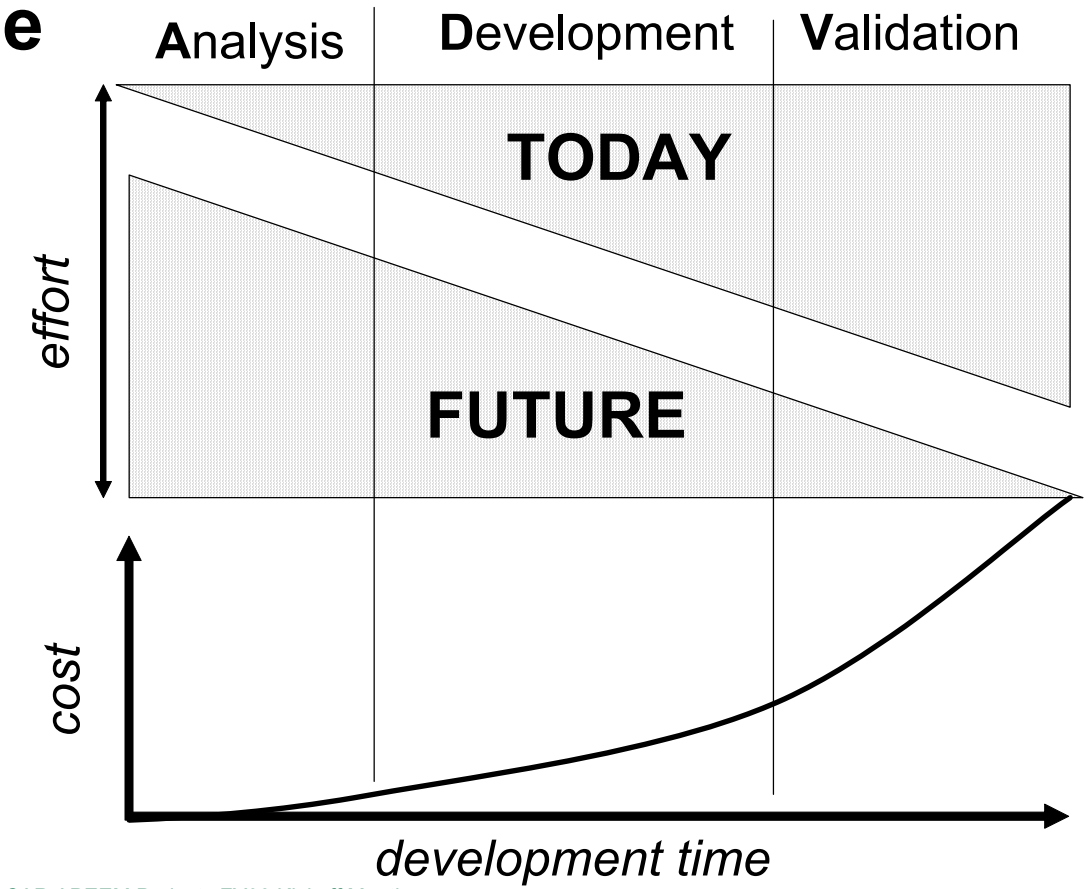
NREL-PR-540-42341

The Problem

- **Fundamental concerns related to PEEM component usage and reliability**
- **Existing methods of addressing reliability are cost and time intensive**
- **For the DOE: Lack of method to quantify 15 year life target**

Description of Technology

- **Flexible reliability modeling tool(s) for automotive power electronics**
- **Allow life/ reliability to be addressed earlier in the design phase**

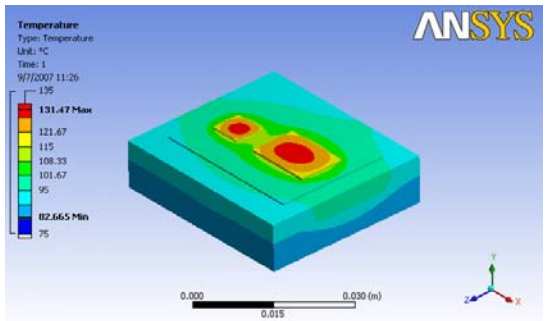


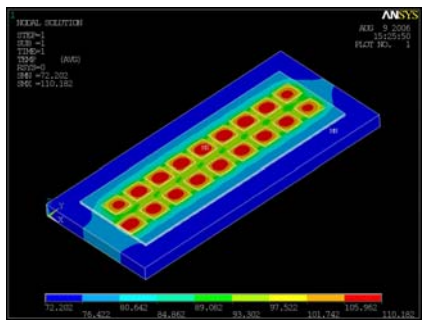
Uniqueness of Project and Impacts

- Develop critical areas not being addressed
- Integrate, leverage, and coordinate
  - testing at ORNL, ANL, and INL
  - thermal modeling at NREL
  - physics of failure experts
  - knowledge from automotive OEMs and suppliers
- Impacts
  - Assess 15 year life target for DOE R&D
  - Empower designers and integrators to address life/ reliability earlier in the design cycle

Accomplishments to Date
(for projects funded in prior FYs)

- Project discussions initiated in FY07
- Discussion of project with industry ongoing
- Thermal system models built



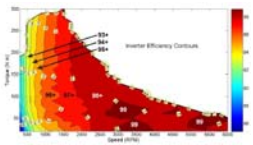


Vehicle Test Data

PSAT Prius Model

MG2 Shaft Torque and Speed

ORNL Inverter Loss Map



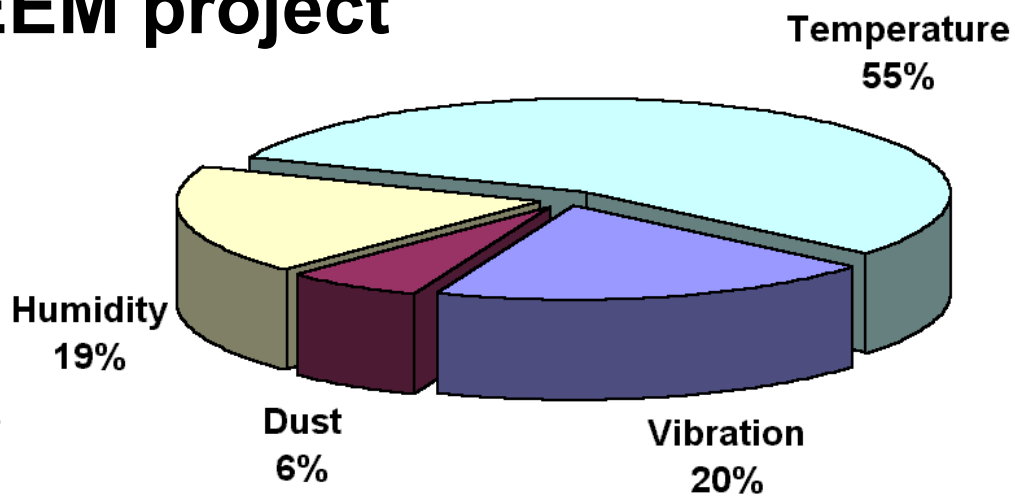
? Reliability ?

Temperatures

Heat Generation

Project Objective for FY08

- Develop a computer tool that can be used by industry and DOE program to predict reliability of PEEM components
- Use the tool to assess one aspect of the life target for an APEEM project



Source: U.S. Air Force Avionics Integrity Program

Reynell, M. 1990

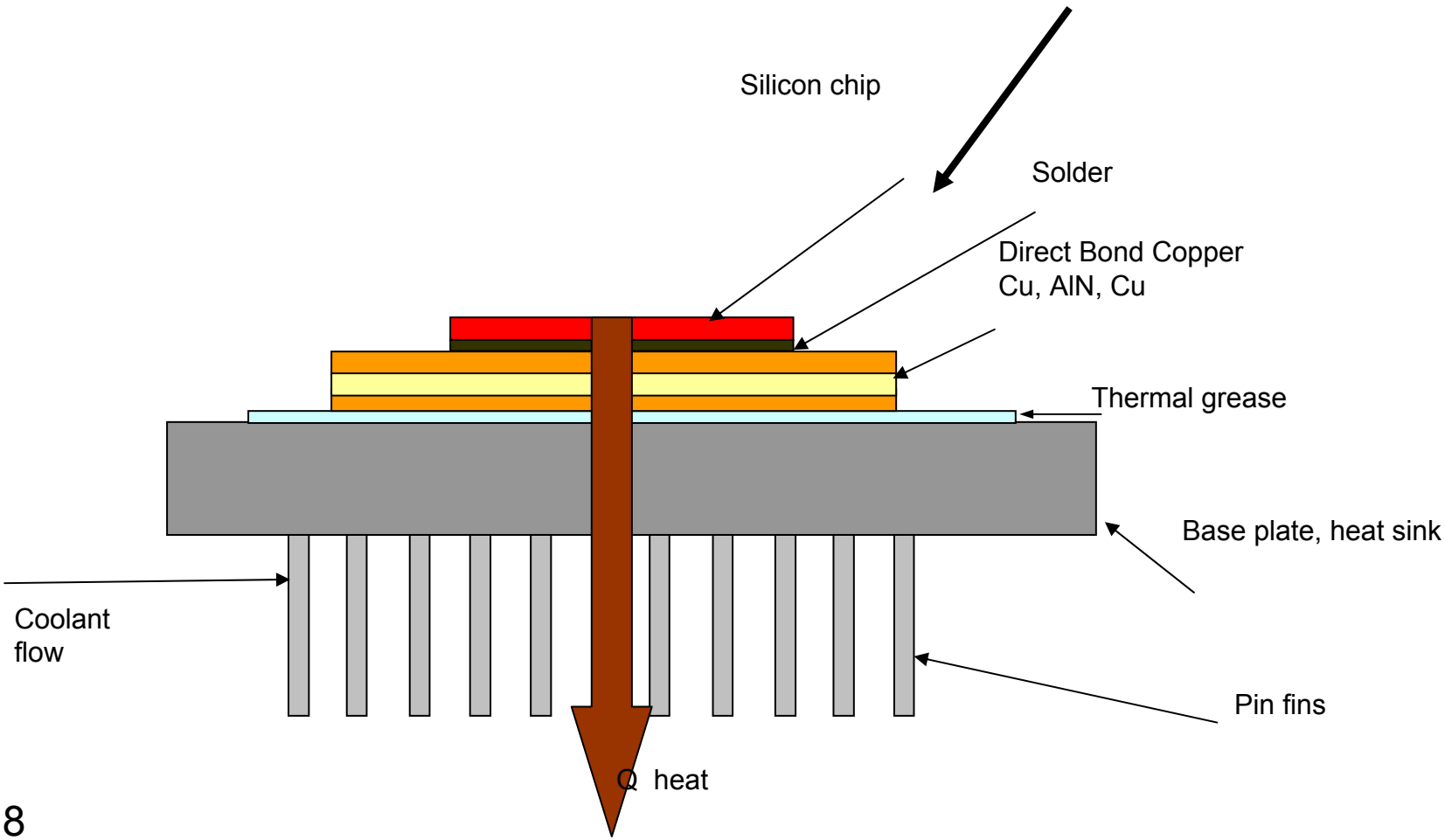
MAJOR CAUSES OF ELECTRONIC FAILURES
(note: not POWER electronics)

Technical Approach for FY08

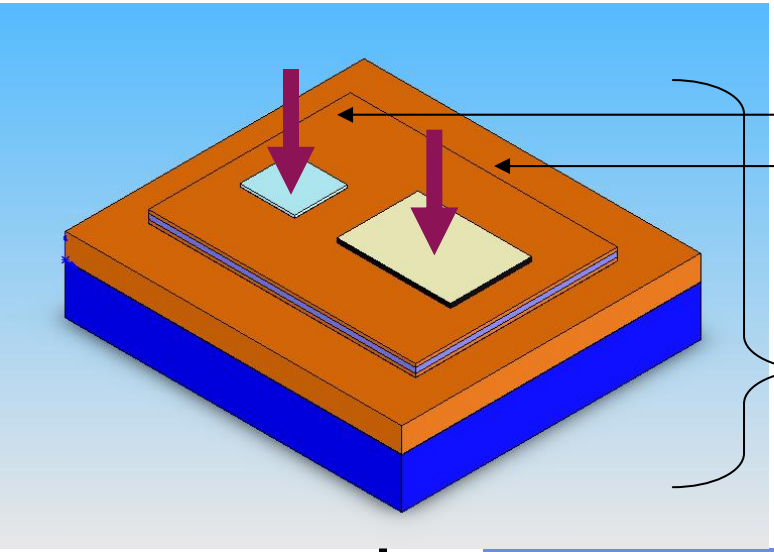
- Develop detailed plan of action for project (03/2007)
- Milestone: submit report on project plan (06/2007)
- Integrate one working model into the tool suite (09/2008)

Vision for Reliability Tool

User specifies heat input, loadings materials and architecture

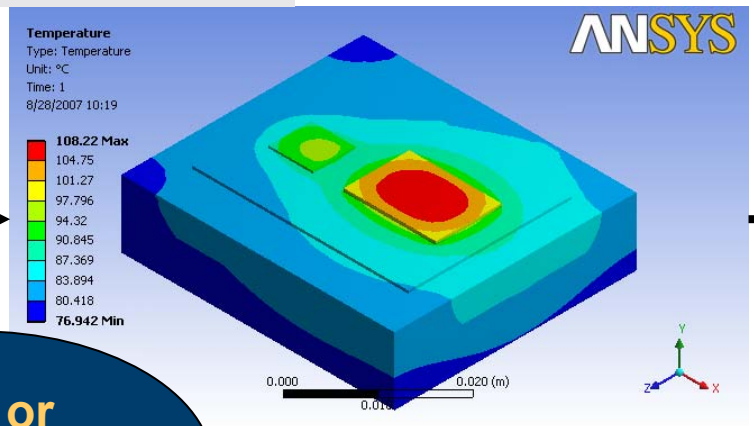


Thermal models can map loads to stressors



Thermal Loading (HEAT GENERATION)

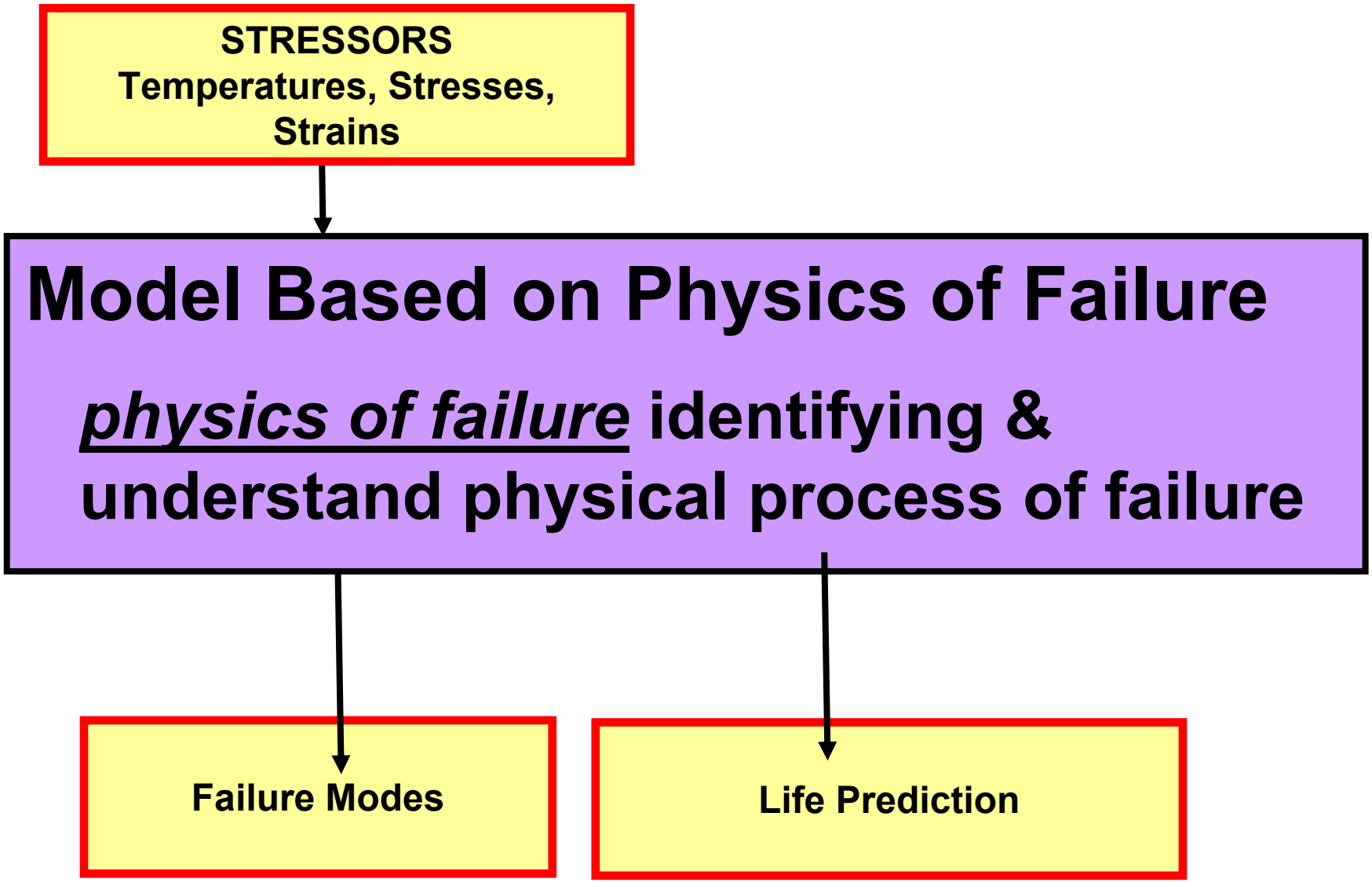
Design Information (Geometry & Materials)



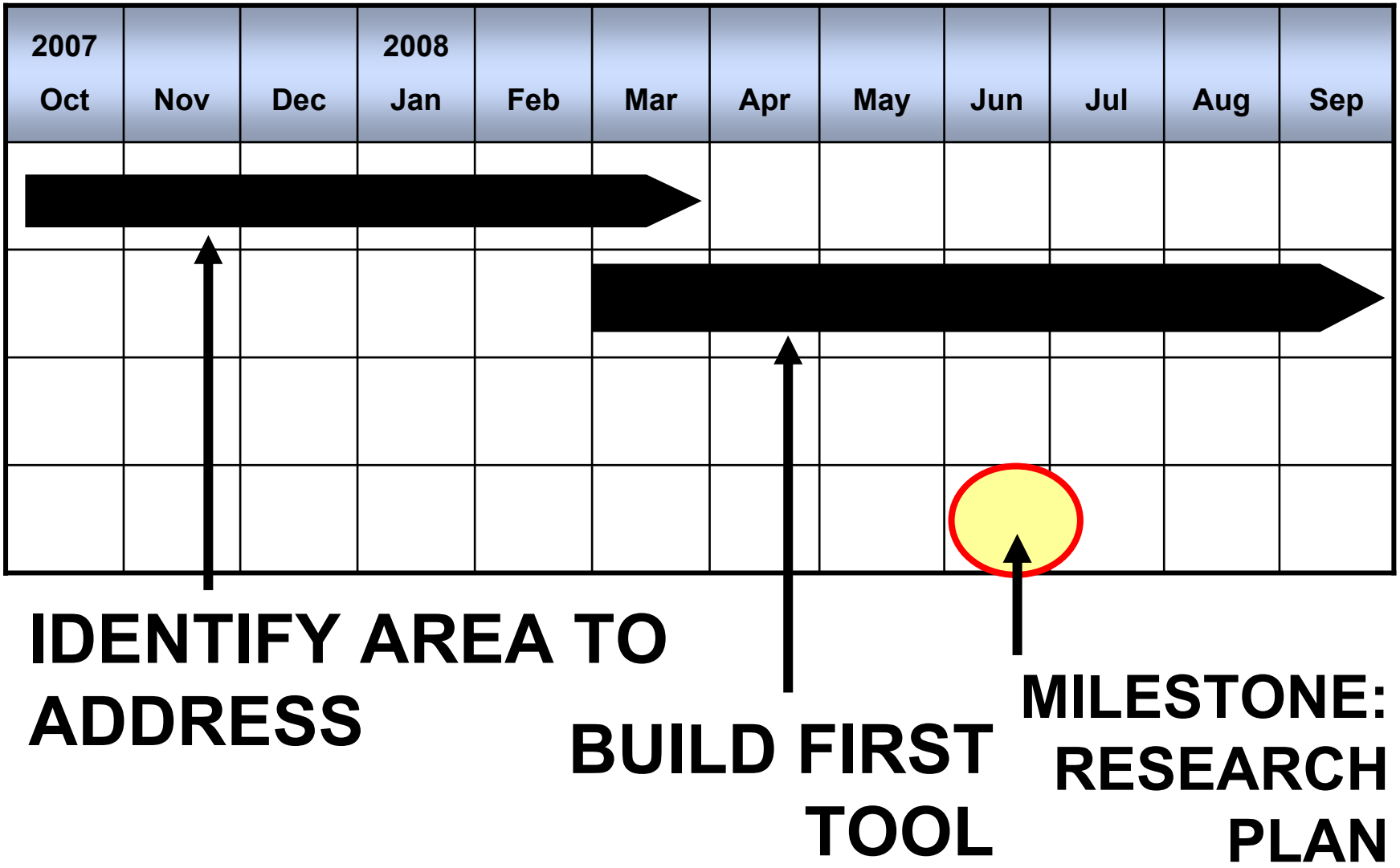
FEA or Fast Network Model

STRESSORS Temperatures, Stresses, Strains

Life is predicted with physics of failure models



Timeline


2007
Oct
Nov
Dec
2008
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
IDENTIFY AREA TO ADDRESS
BUILD FIRST TOOL
MILESTONE: RESEARCH PLAN

The Challenges/Barriers

- Integration and coordination of various engineering software tools
- Validation of models (availability of data)
- Complexity of problem
- Validation of predictions

Beyond FY08

- **FY09**
  - **Application of tool to APEEM program**
  - **Expansion of tool to cover more areas**
  - **Validation activities**

- **FY10**
  - **Finish validation and development activities**

Summary

- Develop Automotive PEEM Reliability Tool
- Process:
  - Starting slow
  - Create a working example early on
  - Adjust as we go
  - Identify opportunities to validate
  - Review progress periodically with DOE and National Laboratory team, OEMs, suppliers and other stake holders

Questions